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# AN EFFICIENT SYSTEM FOR HARVESTING SAND PINE BIOMASS

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**Abstract.**--An efficient system for harvesting Ocala sand pine (Pinus clausa var. clausa D. B. Ward) has been developed by a logging contractor. It is a highly mechanized operation using feller-bunchers, grapple skidders, and an on-site chipper. High quality wood chips are produced because the limbs and needles are left on the area and the chipper separates out much of the bark, which is captured for use as boiler fuel. The operation features integrated use of raw materials with the option to use chips as feed for the paper mill, or as fuel for the boiler during periods of high oil prices. Limbs and needles (which would produce only low-quality fuel) are instead left on site as an important nutrient source for future forest crops on these poor soils.

**Additional keywords:** felling, fuel biomass collection, green weight, piling, residues, windrow.

Forest biomass potentially available for use as fuel is composed largely of undesirable species, low-grade individual trees, and low-grade tree portions. Although its use has increased significantly over the last 10 years, a large portion of the fuels biomass available in the forest is still under-utilized. This material is not being utilized more because the cost of harvesting and transporting it is about equal to its value at the plant site (Stuart 1986). If the harvest costs could be reduced, it would become economical to utilize more of this material. For a variety of very good reasons, as outlined by Stuart (1986), very little research has been done on better biomass harvesting systems. Most of the advances have been in adapting conventional systems for biomass collection. The purpose of this paper is to describe such a system that has been developed for harvesting sand pine biomass.

## HARVEST SYSTEM

This system is based on the use of conventional, readily available tree harvesting equipment. Although no equipment specifically designed for fuel biomass is used, the harvest system is a highly mechanized, high capital investment operation. The system is designed around a 22-inch whole-tree chipper. Wood is supplied to the chipper by four grapple skidders. Felling and piling is handled by two feller-bunchers. Chips and fuel are hauled from the chipper by ten chip-vans and two semi-tractors. Other equipment includes an extra tractor for switching vans on-site, a fuel and a repair truck. Operation of this equipment requires a crew of 10-12 people.

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Growth, however, is reduced considerably for trees on nonprepared areas compared to trees on sites chopped before planting. The purpose of this study was to determine (1) if *strip* site preparation could reduce establishment costs without significantly reducing growth rates, and (2) the effect of strip width on costs and tree growth.

## METHODS

This study was installed on sandhills sites at two locations in Marion County, GA. Both sites had Lakeland soil (thermic, coated, Typic Quartzipsamment) that was underlain by a sandy clay layer at 7 to 9 ft. At each location there were four replications of each treatment in a completely randomized design. The four treatments consisted of different combinations of site preparation and planting configuration. Site preparation consisted of KG-blading or chopping and disking. The KG-blading and chopping were done in July 1972, and the disking was done the following October. The 1-0 Choctawhatchee sand pine seedlings were planted at one location in February 1973 and at the other in February 1974.

One treatment served as a type of control, with site preparation and planting done in a single operation. A 6-ft wide, V-shaped blade mounted on the front of the tractor pulling the planting machine was used to sever vegetation at the ground-line. An 8-ft strip of hardwood scrub was left between the 6-ft planting strips. Tree seedlings were planted 6 ft apart in a single row in the center of each cleared strip. The same tractor with V-blade and Beloit-type planting machine, with planting foot extended 4 in., was used to plant all other treatments. Site preparation for the second and third treatments was done with a 10-ft-wide KG-blade mounted on the front of a tractor. Two passes of the blade cleared strips about 20-ft wide. Treatment 2 like treatment 1, used an intervening leave strip 8-ft wide, but treatment 3

was installed with 16-ft strips of rough between treated areas. In treatment 2, two rows 14 ft apart were planted, with trees about 6 ft apart in the row, while in treatment 3, 3 rows on 9-ft centers were used, with trees spaced at 7 ft within the rows. In treatment 4, a 7-ft Marden single-drum chopper made two passes to clear a 10-ft-wide strip. Later, this strip received a single pass from a 10-ft Rome disk harrow. Trees were planted in the strips 7 ft apart in 2 rows 8 ft apart. Leave strips in this treatment were 14-ft wide. All treatments resulted in a planting density of 519 trees/ac, with an average spacing of 6 by 14 ft in treatments 1 and 2, and 7 by 12 ft in treatments 3 and 4.

A time record was kept for each of the site preparation and planting operations. Seedling survival was assessed at ages 1, 3, and 5 years in each treatment on measurement plots consisting of three rows of trees with 50 planting spots in each. The 1973 plantation was destroyed by a wildfire at age 10 years. Tree diameters and heights were measured on each treatment plot in the 1974 plantation 11 years after planting. Analysis of variance was used to test for significant differences in survival, growth, and yield resulting from treatments.

## RESULTS AND DISCUSSION

The V-blade strips on 14-ft centers and the chop and disk strips on 24-ft centers both re-

sulted in treating less than half of the area (Table 1). Because the strips were wider, more of the KG-bladed area was treated, especially in treatment 2 where these 20-ft strips were done on 28-ft centers. The chop and disk treatment took the longest to do because two passes had to be made. Site preparation by KG-blading took slightly longer in treatment 2 than in treatment 3 because more of the total area had to be covered. Planting time was essentially equal for all treatments. Thus, the lack of prior site preparation did not appreciably slow the planting operation on V-blade treatments. If site preparation had been used, the cost of establishing seedlings would have been about 2.5 times more. Although chop and disk took longer, their cost was about the same as that of the KG-blade methods, both because disking is a less costly operation and because less of the actual area was site prepared. It should be noted that time estimates are conservative compared to what could be expected for larger operations. They are mainly useful for comparing treatments.

The initial survival was much better for the seedlings on all treatments in the second plantation (Table 2). This was attributed to three factors: The quality of the planting stock, the amount of rainfall during and after the planting season, and the time for soil settling prior to planting. The seedlings used in the 1973 planting had not been hardened-

**Table 1. Proportion of area prepared, time, and cost of strip site preparation and planting, by treatment method.**

Treatment method	Area treated (%)	Time to: <sup>a</sup>			Cost of:		
		Site prep	Machine plant	Total	Site prep <sup>b</sup>	Machine plant <sup>c</sup>	Total
		..... (minutes/ac) .....			..... (\$/ac) .....		
V-blade	43	0	18	18	0	25	25
KG-blade (2 row) <sup>d</sup>	71	61	17	78	44	25	69
KG-blade (3 row) <sup>d</sup>	55	48	22	70	34	25	59
Chop & disk	42	128	20	148	42	25	67

<sup>a</sup> Time rates are based on the total land area involved and not just the treated portion.

<sup>b</sup> Cost data from Straka and Watson (1985) was multiplied by the percentage of the area site prepared to give the cost/ac of total land involved.

<sup>c</sup> Calculated by multiplying the number of seedlings planted/ac by the cost to plant a seedling given by Straka and Watson (1985).

<sup>d</sup> Number of rows of trees planted in each strip.

The standard procedure for harvesting a sand pine stand begins with selection of a site for the chipper. Next, this site and a temporary road into it are cleared with the feller-bunchers and skidders. Then felling is begun with accumulated trees laid out in a systematic windrow pattern, with the tops all on one side and the butts on the other (Figure 1). After a number of windrows have been made, a skidder with a load of trees is driven over the tops in the windrows, which breaks most of the branches off the trees. One person with a chainsaw follows to remove any remaining branches. While the felling, windrowing, and limbing is being done, the other members of the crew are moving and setting up the chipper, which usually takes about 1 day. Once the chipper is in place the skidders began hauling tree boles to the landing for chipping into the waiting vans.

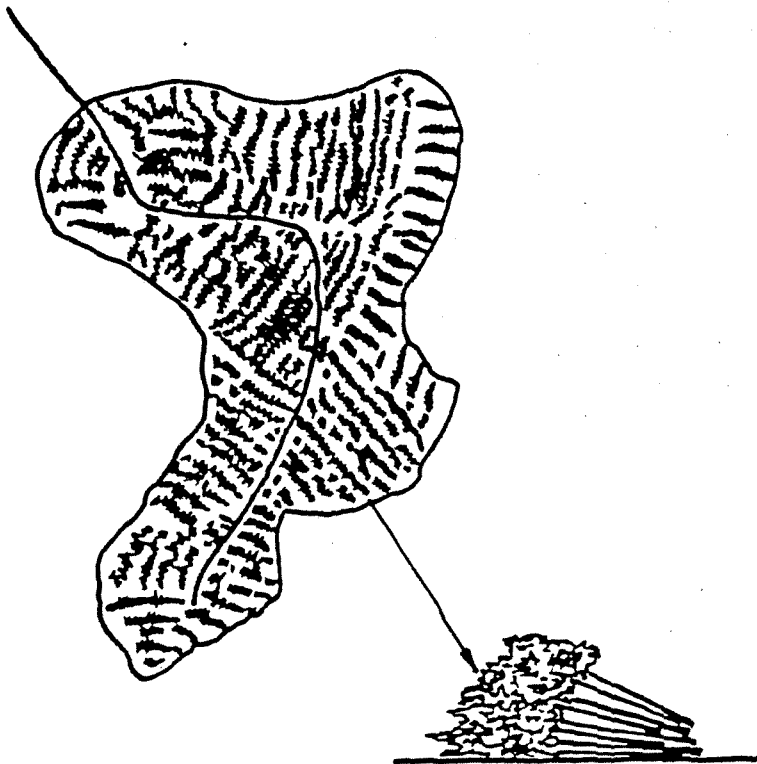


Figure 1.--Diagram of actual harvested site in Ocala National Forest, Florida, and sketch of typical windrow cross section.

On average, one load of chips is produced every 30 minutes. It takes about 9 minutes to actually chip the wood into the van. From 5 to 6 minutes are required to change vans, and an additional 15 minutes is used to skid wood to the chipper in preparation for use. In a normal day about 10 acres will be harvested producing 20 loads of chips, with a green weight of about 620 tons.

The chipper being used employs a series of screens and fans to separate the bark from the wood chips, blowing each into their respective vans for transport to the mill. This system has a depletion ratio of about 4 or 5 to 1. Thus, using sand pine boles, which are about 13 percent bark (McNab et al. 1985), would yield chips with a bark content of about 3 percent. At the mill the bark is used as biomass fuel while the wood chips are normally used as raw material for production of paper products. However, during periods of high oil prices, wood chips can and have been diverted to the boilers for use as fuel.

### SUMMARY

This harvest system has a number of advantages. First, as previously noted, it uses reliable, readily available equipment designed for the woods. Because it is highly mechanized it has a high production capacity which fosters the economic harvest of even small diameter stems of this very limby species. The limbing procedure and the bark separation process result in the production of very clean chips for use as raw material for high grade papers. This harvest system allows integration of raw material uses, which is necessary for a successful operation (Roetheli 1986). Thus, the clean chips can be used as raw material for the pulp mill or as fuel for the boilers as needs and prices warrant. Finally, this harvest system has potential applicability in other areas and timber types. In mixed pine-hardwood stands for example, the hardwoods could be accumulated for chipping for fuel following the chip harvest of the pines for raw material for the mill.

Since the limbs and needles are left on the site, some might view this harvest system as rather inefficient. However, this was deliberately designed into the harvest system. Sand pine grows on nutrient-poor, sandy soils. The limbs and needles are more valuable as organic matter and as a nutrient source than as fuel. It is important to consider the on-site worth of residues when designing a harvest system and not assume that an efficient system must capture all of the available biomass.

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